

A Survey of Vegetation and Wildland Fire Hazards on the Nevada Test Site

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Abstract—In the springs of 2004, 2005, and 2006, surveys were conducted on the Nevada Test Site (NTS) to characterize vegetation resources and climatic components of the environment that contribute to wildland fires. The NTS includes both Great Basin Desert and Mojave Desert ecosystems and a transitional zone between these two deserts. The field surveys assessed 211 sites along major NTS corridors for the abundance of native perennial and annual species and invasive weeds. The abundance of fine-textured (grasses and herbs) and coarse-textured (woody) biomass was visually estimated on numerical scales ranging from zero to five. Distribution of biomass is shown in Geographic Information System maps by NTS operational area. Precipitation on the NTS from January through April of 2004, 2005, and 2006 was above average. There has been an average of 11 wildland fires per year on the NTS over the past 28 years with an average of about 239 acres (97 hectares) per fire. A map showing the location and description of historic fires is presented. The three most commonly observed invasive annual plants to colonize burned areas are Arabian schizmus (*Schizmus arabicus*) at low elevations, red brome (*Bromus rubens*) at lower to middle elevations, and cheatgrass (*Bromus tectorum*) at middle to higher elevations. Colonization by invasive species increases the likelihood of future wildland fires because they provide abundant fine fuels that are more closely spaced than native vegetation. Blackbrush (*Coleogyne ramosissima*) vegetation types appear to be the most vulnerable plant communities to fire followed by pinyon juniper/sagebrush vegetation types. Wildland fires are costly to control and to mitigate once they occur. Recovery of burned areas is very slow without reseeding or transplanting with native species and other rehabilitation efforts. Untreated areas become much more vulnerable to future fires once invasive species, rather than native species, colonize a burned area.

Introduction

The Nevada Test Site (NTS) is operated by the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. It occupies approximately

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1,375 square miles (356,123 ha) of desert and woodland terrain 70 mi (113 km) northwest of Las Vegas, Nevada. The NTS lies on the transition between the Mojave and Great Basin deserts; consequently, the flora and fauna consist of species characteristic of both deserts. Ten major vegetation alliances have been described (Ostler and others 2000) on the NTS. The ecology of the site has been studied extensively for more than 40 years (Webb and others 2003; Wills and Ostler 2001). The presence of wildland fires at the site have also been previously described (Hansen and Ostler 2004). The importance of wildland fires in shaping the ecology of the Mojave and Great Basin deserts is reported in numerous papers in these proceedings.

Wildland fires on the NTS are costly to control and to mitigate once they occur. Recovery of burned areas is very slow without reseeding or transplanting with native species and other rehabilitation efforts. Untreated areas may become much more vulnerable to future fires once invasive species, rather than native species, colonize a burned area. A need was recognized for a relatively rapid method of identifying where wildland fire hazards (in other words, the amount of fine-textured fuels such as grasses and forbs, and coarse-textured fuels such as woody shrubs and trees) occur on the NTS and for quantifying such hazards spatially and temporally. It was recognized that hazards are significantly influenced by the fuels that are produced by winter and spring precipitation (Hansen and Ostler 2004). In 2004 a road survey was designed and implemented to assess wildland fire fuel hazards and to summarize data for management of wildland fires and natural resources of the site. This paper describes the results of roads surveys conducted during 2004, 2005, and 2006.

Methods

Records describing wildland fires for the period of record from 1978 to 2006 were collected, reviewed, and summarized to determine the location, cause, size, and frequency of wildland fires on the NTS. Geographic Information System maps were then created to show the distribution of historic recorded wildland fires and major corridors on the NTS. From this information, road routes were established with sampling intervals varying from 1 to 2 mi (1.6 to 3.2 km) between stations. Exact distance between stations was adjusted to avoid roadside disturbances or where highway conditions, such as curves in the road or lack of sufficient road shoulder width to pull off, created safety hazards. As many of the NTS operating areas as possible were included and sampled in the route, consistent with the size of the

area (in other words, smaller areas had less sampling stations than larger areas). A total of 211 sampling stations were selected.

Scale values for fine fuels and woody fuels were then defined, based on a knowledge of the range of biomass conditions present on the NTS (Ostler and others 2000). The fuel scale values used were

- 0 = Little or no biomass present,
- 1 = Very little biomass present,
- 2 = Little biomass present,
- 3 = Moderate biomass present,
- 4 = High biomass present, and
- 5 = Very high biomass present.

Digital pictures were then taken to document this range of biomass conditions for both fine fuels and woody fuels at several sites. Fuel ratings for fine fuels and woody fuels were added together for each site to give a combined fuel rating that ranged from 0 to 10. Additionally, a data sheet was designed to record the presence of the top three species of woody plants (listed in order of apparent biomass from greatest to least), top four species of herbaceous plants (from greatest to least), and top three species of invasive annuals (listed from greatest to least).

The survey was conducted during the spring of each year from mid-April to mid-May when fuel biomass was near maximum, starting at the lower elevations and working into the higher elevations. Survey stations were located 164 to 328 ft (50 to 100 m) from the roadside to avoid disturbances associated with maintenance of the roads and the abundance of invasive species frequently found along the road edges. Geographic Positioning Satellite (GPS) coordinates were recorded to document the location of sampling points and a digital photograph was taken to document site conditions.

Precipitation data were summarized from seventeen meteorological recording stations, National Oceanic and Atmospheric Administration, Air Resources Laboratory/Special Operations and Research Division (NOAA ARL/SORD stations as reported for May 22, 2006), for the NTS for the period of record for each station for the months of January, February, March, and April. Precipitation at each recording station was given equal weighting and averaged for all 17 stations. Percent increase or decrease from the site average was used to indicate a measure of above or below average precipitation for the year compared to the long-term average, based on the mean over the period of record (approximately 46 years). Lightning data were based on 8 years of warm season data as reported by NOAA ARL/SORD in North Las Vegas, Nevada (Randerson and Sanders 2006).

Results and Discussion

Based on interpretation of aerial photographs, fire scars, species composition, and other evidence observed in the field, it appears that wildland fires have been common and have contributed to the patterns of vegetation observed at the NTS. Historical records (table 1) suggest that there have been an average of approximately 11 fires per year on the NTS since 1978, and that the average area burned per fire was about 239 ac (97 ha). A chart of the distribution of wildfires on the NTS since 1978 is shown in figure 1. The

Table 1—Number and acreage of wildland fires on the NTS.

Year	Fires	Acres	Hectares
1978	10	7,901	3,197
1979	6	2	1
1980	26	13,504	5,465
1981	13	7	3
1982	6	2	1
1983	16	18,291	7,402
1984	17	1,132	458
1985	11	1,609	651
1986	12	236	96
1987	14	213	86
1988	23	821	332
1989	15	323	131
1990	7	7	3
1991	4	4	2
1992	12	239	97
1993	7	7	3
1994	8	15	6
1995	8	4,605	1,864
1996	2	1,700	688
1997	6	15	6
1998	9	2,580	1,044
1999	7	50	20
2000	11	151	61
2001	8	490	198
2002	7	360	146
2003	4	4	2
2004	8	8	3
2005	31	13,000	5,261
2006 ^a	16	9,000	3,642
28-year total	324	76,276	30,869
Average per year	11	2,630	1,064
Average per fire		239	97

^aNumber of fires and area through August 7, 2006. (Source: NTS Fire Incident Reports and personal communication with James A. Brown, Fire Marshal, NTS, August 7, 2006.)

distribution of fires by months (fig. 2) indicates a fire season of June, July, and August.

Most of the historical wildland fires during the past 40 years were located at mid-elevation ranges and mostly within foothills in the blackbrush (*Coleogyne ramosissima*) plant communities (fig. 3). These plant communities are well adapted to drought and are often found with few green leaves during periods of drought. The fine diffuse branching structure of blackbrush makes it particularly vulnerable to fire. These shrub communities have seen increases in red brome (*Bromus rubens*, drier sites) and cheatgrass (*Bromus tectorum*, wetter sites) during the past half century, which contribute to their increased susceptibility to wildland fire. Once burned, these communities that were once dominated by blackbrush are colonized by more fire-resistant shrubs such as joint fir (*Ephedra* spp.) and rabbitbrush (*Ericameria* spp.). Recovery of blackbrush communities burned by wildland fires

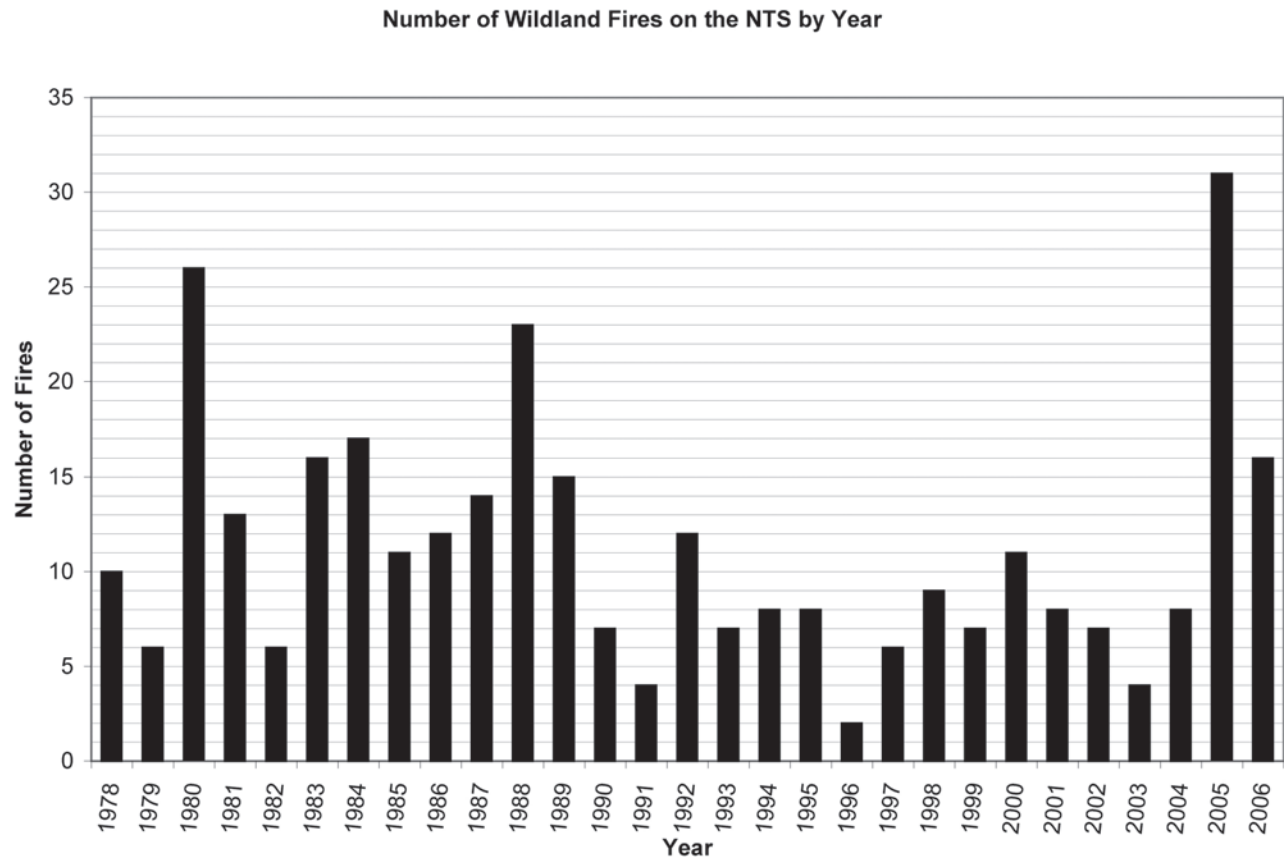


Figure 1—The number of wildland fires on the NTS by year since 1978.

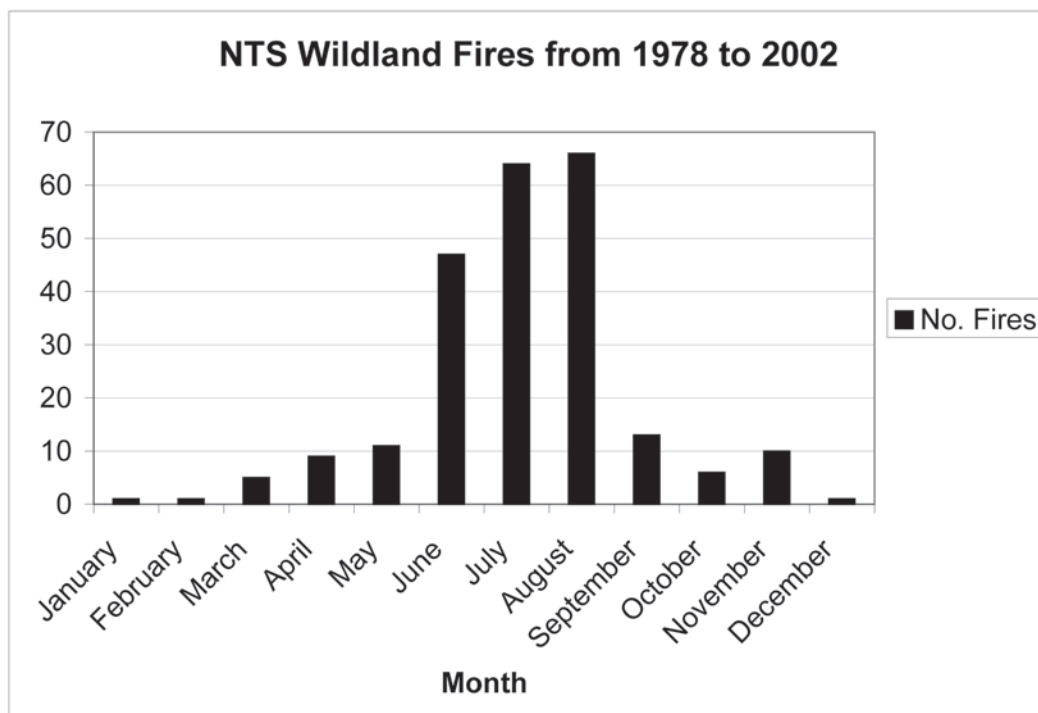


Figure 2—The total number of wildland fires on the NTS by month for the period from 1978 to 2002, indicating an active fire season of June, July, and August.

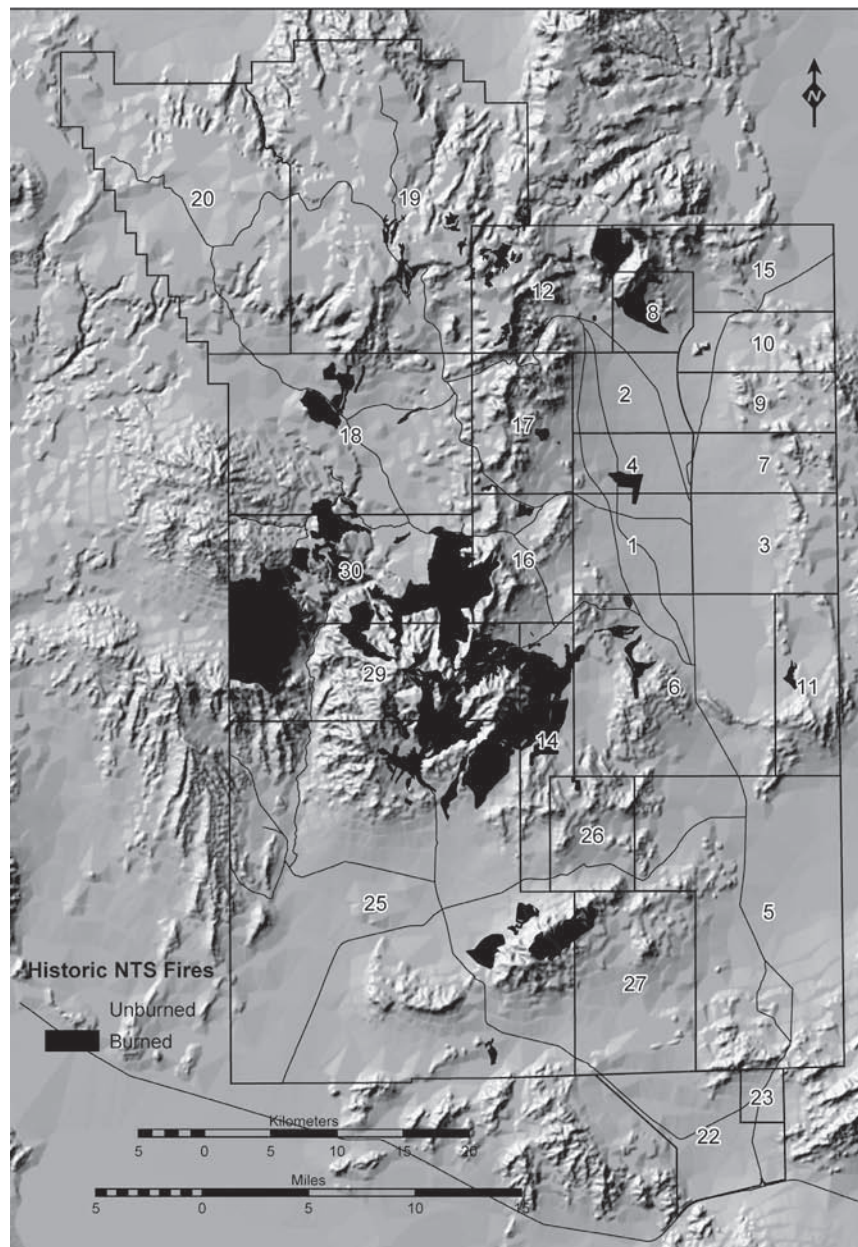


Figure 3—Location of historic wildland fires on the NTS in predominantly middle elevations.

is very slow and rare. Wildland fires are more frequently found in this vegetation than in woodland vegetation such as pinion juniper/sagebrush types, despite the fact that these latter vegetation types receive more lightning strikes during the warm season. The difference in susceptibility is probably due to the relative lack of understory grasses in pinion juniper types compared to blackbrush types and the greater water content in foliage of these trees compared to the foliage of blackbrush shrubs.

Lightning is responsible for the majority of wildland fires on the NTS. Large acreages of land burned in 2005 and 2006 (more than 8,903 ha; 22,000 ac) due to lightning, make this

cause the source of the largest loss of land area burned by wildland fires on the NTS. While other causes of wildland fire are reported as occurring less frequently, these causes are still responsible for large portions of burned area. For example, during the period of 1978 to 1987 it can be calculated that 41.2 percent of the area burned was from vehicle exhaust, 39.3 percent from lightning, 15.2 percent from military and security training, 4.1 percent from unknown causes, and less than 0.2 percent from smoking, construction, and other human-related activities. Data were still not available for the years 1994, 1996, 1997, 1998, 1999, 2003, 2004, and 2005, because recording practices switched from

a paper log to a digital log that did not specifically identify wildland fires. The switch in recording practices made it difficult to identify and separate such fires and their causes from other emergency call outs, which were numerous.

Eight years (1993 through 2000) of warm-season (June through September) lightning data on the NTS have been summarized by Randerson and Sanders (2006). For the eight warm seasons, a total of 9,596 cloud-to-ground (CG) lightning flashes (fl) were detected. For the approximately 1,375 mi² (356,123 ha) of NTS, this total yields an average NTS warm-season flash density of 0.137 fl/mi² (0.356 fl/km²). Climatologically, CG lightning activity begins to develop rapidly after 1100 Pacific Daylight Time (PDT), reaching a peak between 1400 and 1459 PDT over the mesas and between 1500 and 1559 PDT over the southern half of the NTS. Although CG lightning has occurred during every hour of the day, minimum CG lightning occurs between 0600 and 1100 PDT, with 0800 to 0859 PDT being the hour of least CG activity. Maximum daily warm season flash densities ranged from 1.2 to 2.7 fl/mi² (3.0 to 7.0 fl/km²). The most active thunderstorms generated CG flash rates of 50 to 75 fl/hr. Average spacing between successive CG flashes was 3.4 mi (5.5 km), and 77 percent of these flashes were 5.0 mi (8 km) apart. Maximum separation detected was 11.9 mi (19.2 km).

Historically, most large burns on the NTS occurred during late summer (late July or early August) as compared to early spring, correlating with monsoonal storm patterns that were accompanied with lightning. Areas of maximum lightning activity are typically located in mountainous areas in the northern, upper elevation ranges of the NTS. Although these areas receive more lightning, they do not necessarily result in more wildland fires; either the vegetation in these areas does not catch fire as readily or the fire does not spread when ignited as it does in the blackbrush communities. It appears that understory invasive grasses contribute significantly to increased hazards of wildland fires, especially when located in blackbrush communities.

Late winter and early spring precipitation (January through May) at the NTS during the first year of the

wildland fire survey (2004) was 4 percent above average and was considered typical of recent precipitation at the NTS during the past two decades (table 2). However, the late winter and early spring precipitation at the NTS during 2005, the second year of the survey, was 67 percent above average and was distributed early in the year and more or less evenly across most of the NTS. This precipitation initiated germination of many invasive species of grasses and native annual species (table 2). Biomass of annual species was very apparent by the end of May 2005. Maximum growth of above-ground biomass of woody species in 2005 occurred later in the summer and early fall. Increases in shrub diameter were not very noticeable; however, height and foliar density of individual shrubs or trees was very apparent based on comparisons of shrubs and trees in site photographs. Late winter and early spring precipitation in 2006 was less than in 2005, but was still about 20 percent above average. This precipitation resulted in only modest amounts of annual and perennial biomass; however, the fuels persisted from the 2005 growing season and added to the total 2006 fuel loading with levels approaching, or in many cases exceeding, those observed during 2005 (fig. 4).

Scalar values for fine fuels and woody fuels were higher at most of the 211 sites. Sites with thin, rocky soils (for example, sites with desert pavement or in exposed bedrock) had very little change in the magnitude of response due to changes in precipitation from dry to wet years. Moisture apparently moved too quickly through the thin soils by percolation or runoff thereby limiting plant-available moisture and subsequently plant growth. Other sites that exhibited little change in scalar values were sites located on deeper soils where soil moisture was high, thereby always encouraging maximum fine and woody fuels. Such sites were often typical of drainages where soil fines, moisture, and plant nutrients tended to accumulate. Other variances in scalar values of fuels could also be observed each year among a few of the 211 sites regardless of average sitewide trends because of the nonuniform distribution of precipitation where thundershowers would deliver rain to some watersheds, but not others.

Table 2—Precipitation history and percent presence in surveyed sites (top species contributing to fine fuels).

Precipitation history	2004	2005	2006
-- percent above average --			
Precipitation (January–April)	4	67	20
Invasive introduced species	2004	2005	2006
--- percent presence ---			
<i>Bromus rubens</i> (red brome)	51.7	64.4	67.8
<i>Bromus tectorum</i> (cheatgrass)	40.3	54.0	60.7
<i>Erodium cicutarium</i> (redstem stork's bill)	5.2	6.2	24.6
<i>Schismus arabicus</i> (Arabian schismus)	4.7	2.8	5.2
Native species	2004	2005	2006
--- percent presence ---			
<i>Amsinkia tessellata</i> (bristly fiddleneck)	34.0	62.0	16.1
<i>Mentzelia albicaulis</i> (whitestem blazingstar)	49.8	8.1	0.0
<i>Chaenactis fremontii</i> (pincushion flower)	27.0	8.0	0.0

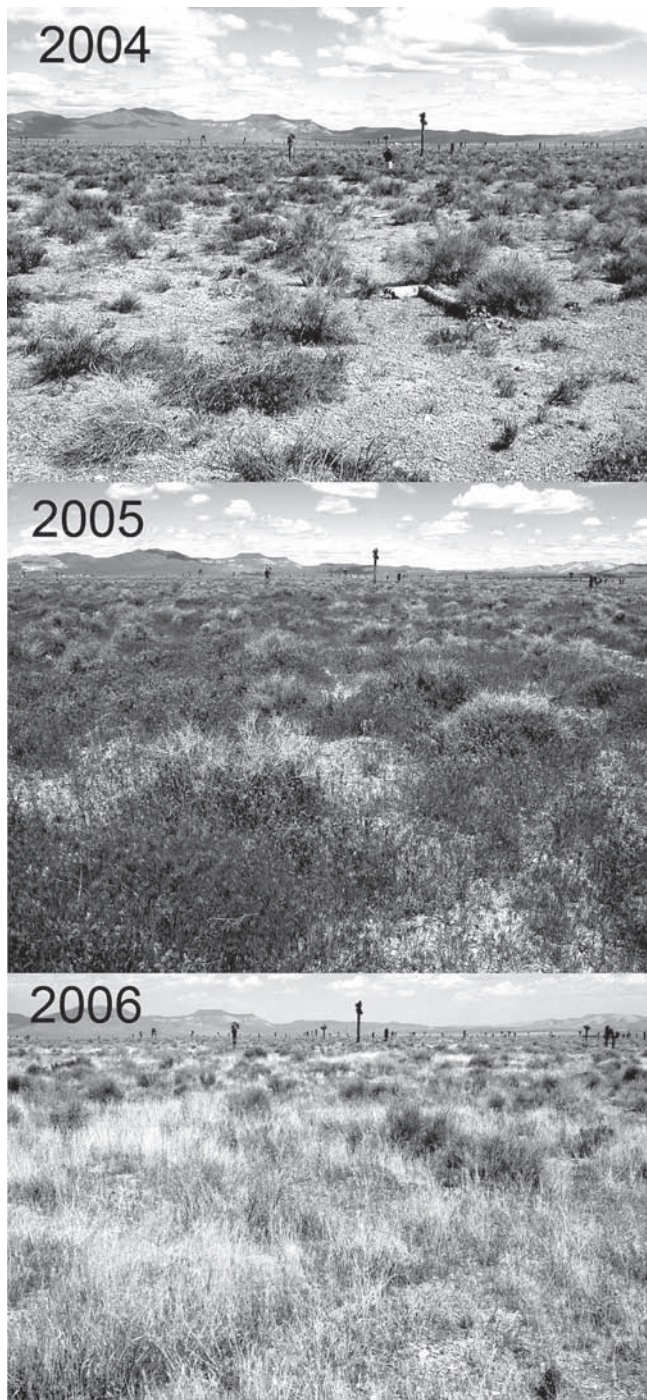


Figure 4—Presence of fine fuels at Site 99 in Yucca Flat on the NTS over three years (2004, 2005, and 2006 had about 4, 67, and 20 percent above average precipitation, respectively).

Scalar values for fine fuels and woody fuels were each plotted separately to provide GIS maps showing the color-coded values and locations of the 211 sites. Maps of woody fuels did not show appreciable changes in scalar values over the three-year period, however, an evaluation of maps of fine fuels showed that scalar values for sites were more responsive to increases in precipitation than woody fuels. When the six-point scalar values of fine fuels were equally weighted and added together to create an 11-point scalar index for each sampling stations, the resulting map is considered more indicative of wildland fire hazards (fig. 5). This combined index reflects the fine fuels needed to start a wildland fire (for example, catching sparks from a lightning-struck shrub or tree) and the woody fuels needed to carry a fire (such as raising the quantity of fuels and elevating the flame height). An evaluation of old wildland fire sites on the NTS indicated that sites that were exclusively fine fuels or woody fuels did not maintain wildland fires as well as sites with a combination of fine fuels and woody fuels. This observation was also apparent in the field where recently burned areas that were plentiful with invasive grasses did not carry a fire until the sites had aged sufficiently to produce some woody biomass. The presence of strong wind was also observed as a modifying condition that could cause wildland fires to burn through areas that contained predominantly one type of fuel.

Conclusions

Ecological field evidence suggests that wildland fires have been historically present on the NTS, but are increasing in area and importance as invasive grasses provide more fine fuels to carry fires ignited by lightning from shrub to shrub and tree to tree. Species composition data suggest that plant communities like blackbrush provide both woody fuels and fine fuels needed for ignition and the spread of wildland fires. The majority of areas burned on the NTS during the past 50 years have been in the blackbrush plant community type, which is recovering very slowly. Most wildland fires are started by lightning that tends to occur late in the summer when monsoonal storms entering southern Nevada create an abundance of dry lightning from convectional local storm clouds. It was observed during this study that fine fuels that result from high winter and early spring precipitation create a major hazard for wildland fires, especially when followed by drought conditions and high temperature in the summer months. High amounts of fine fuels may also carry over into subsequent years. The cost of fighting wildland fires is high and the loss of infrastructure, such as power lines and communication structures, provides an incentive to gain a better understanding of the science and ecology of wildland fires on the NTS, an understanding that will be complicated by the spread of invasive species and higher temperatures that have been observed to increase on the NTS in recent years.

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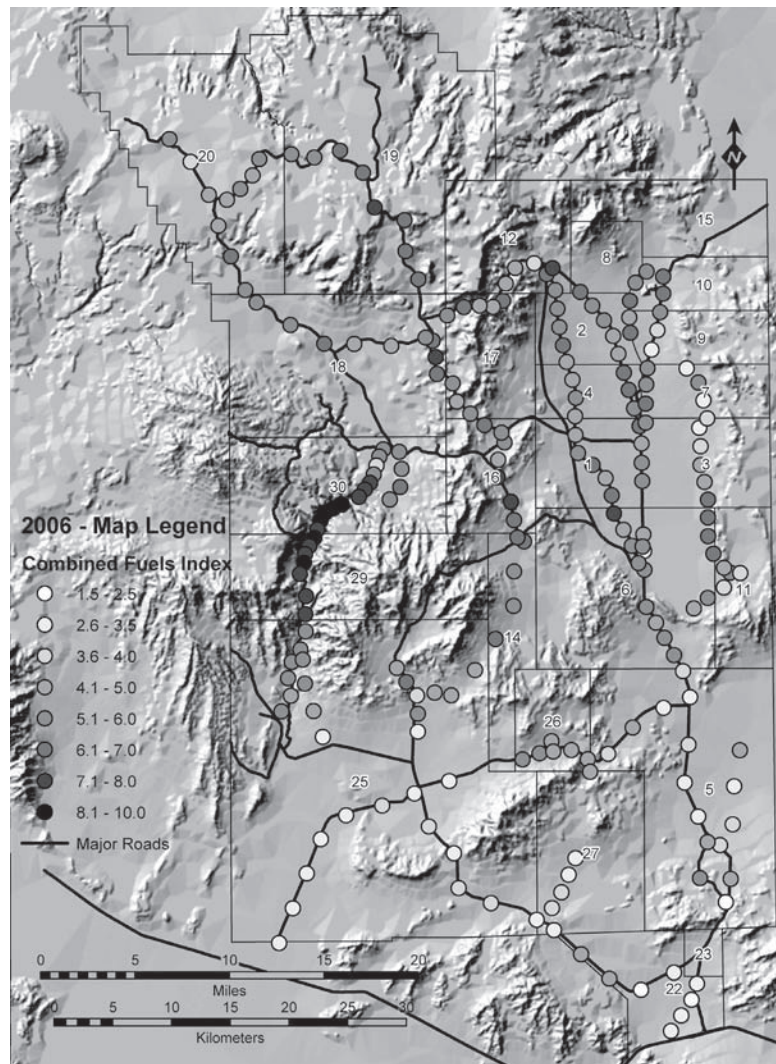


Figure 5—Combined Fuels Index (fine fuels + woody fuels) during 2006 on the NTS (darker colors indicate higher combined fuels, while lighter colors indicate lower combined fuels).

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